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Cardiovascular Disease Overview and Making Healthcare Simply Available via Heartbeat Sensors

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Abstract: Cardiovascular disease (CVD) is the cause of the greatest number of deaths worldwide. It is statistically number one around the globe on that side. The World Health Organization reported that it causes approximately 17 million deaths each year, and approximately 17.9 million people died in 2019. This represents 32% of all global deaths due to heart attacks and strokes, approximately 17.6–19.1 million in 2020, and approximately 18 million in 2021. There is no exact number of deaths in 2023, whereas in Yemen, it is approximately 27848 per 100,000. The latest study of Yemen revealed that approximately 19.39% of people die around the globe, which represents the top 14 in the World Health Organization ranking in 2020. The risk of this disease continues to increase daily, which has led scientists to work on this disease to reduce the number of deaths. There-fore, this study focused on understanding the major forms of cardiovascular illness. Clarifying the amount of research using pulse and ECG sensors to predict heartbeats from 2017–2023, understanding the most frequent variables used to diagnose cardio-vascular disease. In the future, this study will provide a clear view of how to build a model that predicts a person's status and reduces the number of people who die from cardiovascular disease.

Keywords: *Cardiovascular disease, Risk factor, Heartbeat sensors, Real-time IoT diagnosis.*

1. Introduction

The heart is the main circulatory system throughout the body [1]. It not only pumps but also works with other body systems to regulate heart rate and blood pressure [2]. Your family history, personal wellness history, and lifestyle all influence how well your heart works [3, 4]. It works as a circular system. It consists of four main parts (rooms) that are driven by electricity. The brain and nervous system regulate cardiac function [5].

As stated in the World Health Organization, cardiovascular disease or cardiovascular disease is one of the deadliest diseases in the world, as stated in the statistics book in the year 2023, 27% of patients will die from heart disease, 16% from cancer, and 5% from diabetes. According to the World Health Organization, approximately 17 million people die each year, approximately 17.9 million in 2019, accounting for 32% of all global deaths due to heart disease and stroke, approximately 17.6–19.1 million in 2020, approximately 18 million by 2021, and no specific number of deaths per year 2021. In 2023, when approximately 100,000 people were in Yemen, 27,848 people were involved. According to the most recent study in Yemen, it accounts for 19.39% of all deaths worldwide, ranking 14th in the World Health Organization's rankings by 2020 [6, 7], as shown in Figure (1) and Figure (2).

Major cardiovascular diseases are myocardial infarction, congestive heart failure, congestive heart failure, and coronary heart disease [1, 8]. Coronary artery disease (CAD) involves narrowing of the arteries, causing chest pain and heart attack. It also affects the ability of the heart to pump blood to the legs and feet [9]. Abnormal heart rhythms caused by heart disease, diabetes, high blood pressure, or other health issues can lead to heart failure [10]. Heart failure occurs when the heart cannot carry enough blood into the body, which can lead to heart disease, diabetes, coronary artery disease, hypertension, arrhythmias, sleep apnea, and congenital heart defects. Millions of people worldwide are affected by various factors, such as obesity and alcohol or drug use [11]. Valvular problems cause valvular heart disease, resulting in heart murmurs. Causes include infection, birth defects and age. The most common types are aortic stenosis, mitral regurgitation, and aortic regurgitation [12].

Multiple studies have identified several danger factors for cardiovascular disease (CVD), including excessive blood strain, excessive cholesterol, smoking, diabetes, obesity, physical inactivity, circle of relative history, age, sex, and pressure. High blood pressure, cholesterol, smoking, diabetes, weight problems, and physical inaction increase the risk of CHD and stroke. Additionally, high blood cholesterol, smoking, diabetes, obesity, and a physical state of inactivity can also contribute to CVD. Factors including age, sex, and stress can also increase the likelihood of CVD [13-16].

Patients with heart failure often experience symptoms such as chest pain, shortness of breath, fatigue, cough, irregular heartbeat, dizziness and seizures. Tests such as ECG, echocardiogram, stress tests, and blood tests are used to diagnose CVD. Treatment options include lifestyle changes, cardiac rehabilitation programs, bypass surgery, medical solutions, and medications. Prevention of heart

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disease includes regular screening; control of blood pressure, cholesterol, and weight; healthy eating; smoking cessation; and stress management [15, 17].

Several sensors are used to measure and detect the condition of an individual [18]. Lifestyle, low levels of physical activity, stress, smoking and alcohol consumption can be major risk factors for heart disease [19]. Low levels of stress and a healthy lifestyle are key factors in preventing or reducing the incidence of heart disease [20]. Thus, this review discusses the major types of heart disease, risk factors, and diagnostic methods.

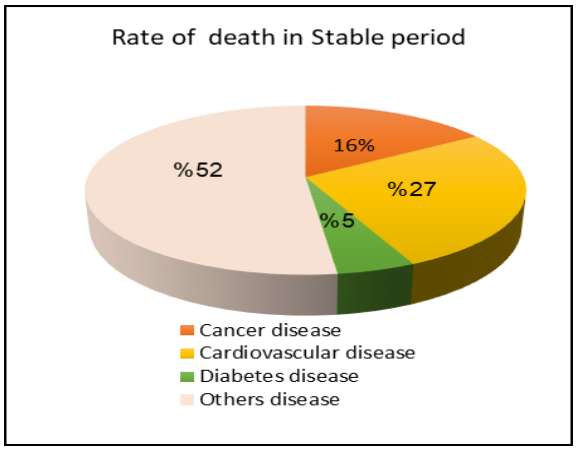

Figure 1. Statistical study for cardiovascular disease in globe comparing to other diseases in stable period

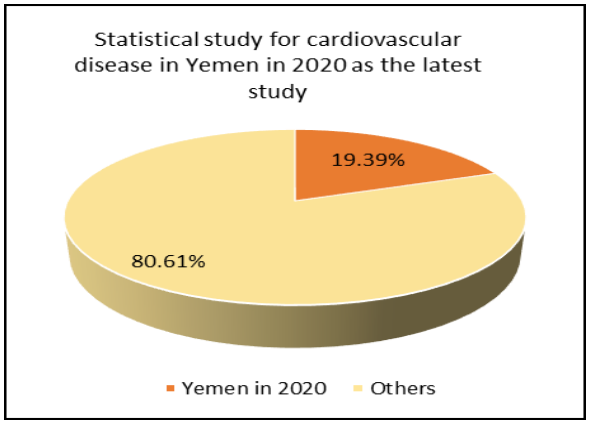

Figure 2. Statistical study for cardiovascular disease in Yemen in 2020 as the latest study

The simple real-time application is used to help a frail client monitor heart status and learn how to monitor their heart in a simple way. As a first step in screening, simple measures using cost-effective equipment can be used to help measure this risk at home. Therefore, the following work has contributed to this work.

- Known major types of heart disease.
- To clarify how many studies used pulse ECG sensors to predict heart rate from 2017--2023.
- Knowledge of the cost of conducting real-time analytics.
- Know the commonly used diagnostic criteria for cardiovascular disease.
- Determine first whether your heart condition looks normal or not.
- Make the test available to a vulnerable user to attempt to check their heart.
- Understanding basic instruments for testing the condition of the heart.

2. Cardiovascular disease

Heart disease, also known as cardiovascular disorder (CVD), refers to a fixed situation that affects the coronary heart and blood vessels[21, 22]. According to the Global Health Organization, coronary heart disease is a worldwide sickness that causes death each year[6, 7, 22]. Multiple types of cardiovascular disorders are discussed, and the main types of cardiovascular disorders are discussed in Section three.

2.1. Classification of the main types of cardiovascular disease

Coronary artery disease (CAD), arrhythmia, heart failure, and valvular heart sickness are the 4 major forms of cardiovascular ailment [1, 8]. A diagram that represents all the principal kinds of heart ailments is represented in Figure (3), and a discussion of each can be found inside the next section.

2.1.1. Coronary artery disease (CAD)

Coronary artery ailment (CAD), also known as arterial sickness or peripheral artery disease (PAD), is one of the most common heart sicknesses [23, 24]. This occurs when the arteries that deliver blood from the heart to the frame become narrower, which can cause chest pain or heart assault [9]. The weakness of the coronary heart occurs when the amount of blood being pumped to the legs and feet decreases [23, 25]. The patient in this situation feels trouble in their legs or toes [23, 25]. This occurs because plaque covers or fills the artery partitions, causing little blood flow into the legs and ft [9, 23, 25]. This plaque results from the increased quantity of cholesterol, fats, and different materials in the blood, as represented in Figure (4).

The maximum common threat elements that could affect CAD are excessive blood stress, high cholesterol, smoking, diabetes, obesity, and a circle of relatives' history [26]. The symptoms that a person can sense after they exercise any bodily hobbies are cramping, leg pain, and fatigue [27]. When these signs and symptoms are ignored, gangrene, tissue harm, and amputation may occur [28].

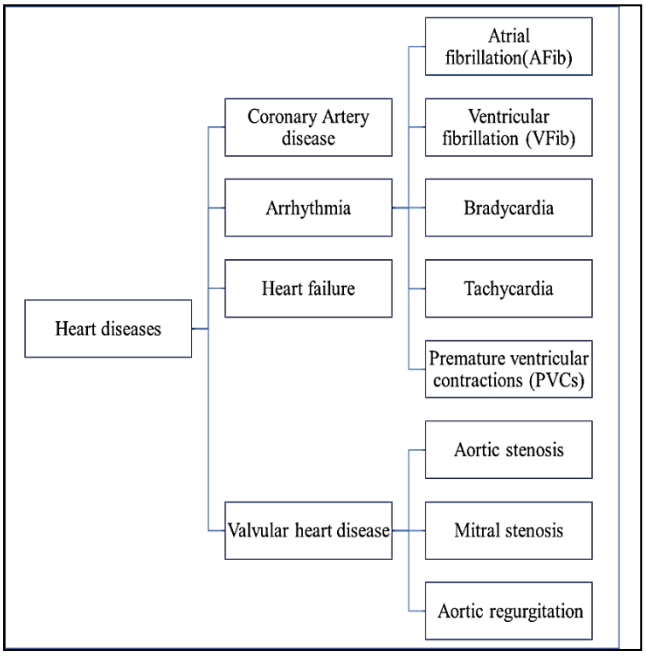

Figure 3. Types of Cardiovascular Disease

The diagnosis of this type of disease should be made via a review of the circle of the patient's history; a bodily examination; an ankle–brachial index (ABI) test, which measures the amount of blood that flows into the ankle, arm, and legs; and a duplex ultrasound test, which is used to obtain an image of the artery to determine whether there is any block in the walls of the artery [29-31].

To reduce the impact of artery disorders, a terrific way of life, such as exercising often, preventing smoking, and ingesting healthy meals and, if there may be a hassle with cholesterol or blood stress, one must have medication to lower the level of blood strain and cholesterol in one's blood [32]. In an essential situation, surgical operation, which includes surgical operation or angioplasty[33], is the quality solution . Skipping surgery is the way to open the blocked artery, whereas angioplasty is an operation that involves removing the artery partitions and allowing the blood flow in the artery as a regular glide with a regular amount of blood instead of a slender or blocked artery [34].

2.1.2. Arrhythmia

When the heart beats too slowly or too fast, resulting in an abnormal heart rhythm or irregular heartbeat, it is referred to as an arrhythmia disorder [10]. It ought to take place for more than one reason, together with having diabetes, excessive blood stress, or some other fitness hassle [10]. There are numerous types of arrhythmias, such as atrial fibrillation (AFib), ventricular fibrillation (VFib), bradycardia, tachycardia, and ventricular contractions (PVCs) [35]. AFib happens when the affected person feels the coronary heart beating too speedy in an irregular manner, in keeping with higher chamber problems (atria). VFib is a dangerous type of arrhythmia, and it occurs when the coronary heart's decrease chambers are fib instead of beating at the ordinary facet on the way to trap the heart. Bradycardia occurs when the coronary heart beats too slowly. Tachycardia also occurs when the coronary heart beats too fast. Premature ventricular contractions (PVCSs) seem when the coronary heart stops all at once and then begins to evolve, beating commonly another time owing to a hassle with the coronary heart's ventricles [35].

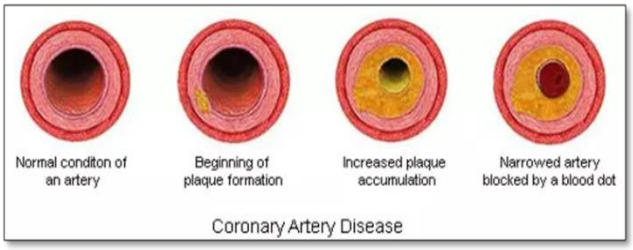

Figure 4. Cardiovascular Artery Disease **(**created with https://ivypanda.com/essays/coronary-artery-disease-normal-physiology-and-pathology/, accessed on 15 March 2024)

In arrhythmia, the most common risk factors rely on the status of the heart, and situations that cause the disorder determine the primary risk elements, whereas in trendy cases, the not unusual hazard factors that might cause arrhythmia are palpitations, chest pain, shortness of breath, fainting, syncope, and lightheadedness [35, 36].

Medical records, electrocardiograms (ECGs), bodily examinations, Holter displays, echocardiograms, occasion recorders, and electrophysiology are used to diagnose this type of disease with the intention of clarifying its reputation and severity[35, 37].

In truth, there may be no unique treatment for this type of disease; the handling depends on the purpose and severity of the ailment. In a few instances, it may be solved by itself when it is grown; in other cases, it may need medication to normalize the pulse, or it could need an operation and extra tools [38].

2.1.3. Heart failure

Heart failure is the status of the heart when it cannot pump enough blood to the whole body [11]. Millions of people worldwide have this common type of disease for multiple reasons, such as coronary artery disease, diabetes, cardiomyopathy (heart muscle disease), heart valve disease, high blood pressure, arrhythmias, sleep apnea, congenital heart defects, or obesity. Alcohol or drug users could also have heart failure [11, 39].

There are a set of factors that lead you to know that you could complain of heart failure, such as shortness of breath, difficulty sleeping, fatigue, difficulty concentrating, pain or swelling in the legs, ankles, or feet, confusion, loss of appetite, an irregular heartbeat, wheezing, or persistent cough[40].

There are a variety of tests that can be used to test for heart failure, such as an MRI or CT scan, a physical examination, a cardiac catheterization test, a stress test, a blood test, an echocardiogram, and an electrocardiogram (ECG) [41].

A healthy lifestyle and medications could reduce the risk of heart failure. In high-risk status, implantable devices such as pacemakers or defibrillators, surgery, or cardiac rehabilitation programs could help. As treatments, eating a healthy diet, having a regular checkup, having a healthy weight, regular checkups of blood pressure and cholesterol levels, quitting smoking, and managing stress are steps to reduce the risk of heart failure [40, 42].

2.1.4. Valvular Heart Disease

Valvular coronary heart sickness occurs when there is trouble with the coronary heart valves, which can cause coronary heart murmurs [12]. There are multiple causes of valvular heart disease, such as infections, congenital heart defects, and age-related effects [21]. Aortic stenosis, mitral regurgitation, and aortic regurgitation are types of valvular disease [43]. However, aortic stenosis occurs when the quantity of blood in the feed body is less than usual due to a narrower aortic valve, which affects the pumping of blood effectively [44]. Mitral regurgitation occurs when the mitral valve, which normalizes blood flow between chambers on the left side, does not close well. In this situation, the blood flows back into the left atrium and causes problems [45]. Mitral stenosis occurs because the mitral valve has difficulty transferring blood from the left atrium to the left ventricle because the mitral valve is narrower [46]. Aortic regurgitation occurs because the aortic valve has difficulty closing well, which causes the flow of blood into the left ventricles [8, 44].

A variety of tests should be taken to ensure that the person has a valvular risk or not, and they are as follows [47, 48]:

1. **Chest X-ray**: This technique detects the accumulation of lung fluid and signs of an enlarged heart.
2. **Echocardiogram (ECG):** This test shows illustrations of the heart and its valves via sound waves.
3. **Electrocardiography**: it detects irregular cardiac rhythms by measuring the electrical activity of the heart.
4. **Cardiac catheterization test:** This procedure involves passing a tiny tube through a blood vessel to the heart to detect blood pressure and determine the degree of valve dysfunction.

3. Risk factors for cardiovascular disease

Heart disease symptoms can include chest pain or discomfort; shortness of breath or difficulty breathing; fatigue; swelling in the legs, ankles, or feet; an irregular heartbeat; dizziness or lightheadedness; and nausea or vomiting [49, 50]. A variety of test

tools, such as electrocardiograms (ECGs), echocardiograms, stress tests, cardiac catheterization, and blood tests, are used to diagnose CVD [51, 52]. Even the severity of a patient's situation affects treatment options, such as changing lifestyles such as a healthy diet and exercise in some cases, whereas in others, a cardiac rehabilitation program, bypass surgery, medical solutions such as angioplasty, and the use of a specific medication could help decrease blood pressure or cholesterol pressure [15, 17].

As stated in numerous studies [13-16, 53-59], cardiovascular risk factors are behaviors or symptoms that increase the likelihood of developing cardiovascular disorders. These behaviors or symptoms include high blood pressure, high cholesterol, smoking, obesity, diabetes, family history, age, physical inactivity, an unhealthy diet, stress, etc. All of the most known risk factors for cardiovascular disease are between 1 and 13. These factors are used to determine whether a person's heat is normal and are represented in Table (1) [60-62]. This table represents the main factors and what was already taken from the sample dataset that concentrated on cardiovascular disease, such as Cleveland: 303; Hungarian: 294; Switzerland: 123; Long Beach VA: 200; and Statlog: 270. The heart rate factor can be used to make the first decision about heart status, whether it is okay or not. This increases the probability of having or developing CVD. Therefore, the main risk factors are described below:

1. **Age**: All ages are susceptible to cardiovascular disease, but the risk increases with age. After the ages of 45 years for males and 55 years for females, it is important to keep in mind that a person's early development of CVD can be influenced by a variety of variables, including genetics, lifestyle choices, and other medical conditions [53].
2. **Gender**: One important risk factor for cardiovascular disease is sex. Cardiovascular disease can affect both men and women, but the risk factors and ways it presents itself are different. In general, males are more likely than females are to develop cardiovascular disease earlier in life. Both the incidence of coronary artery disease and the risk of having a heart attack are increased. Hormonal fluctuations play a role in this process, with estrogen providing some protection for women before menopause. However, women's risk of cardiovascular disease increases dramatically after menopause. This is caused by a decrease in the protective properties of estrogen. In addition, women are more likely than men to have uncommon symptoms, including fatigue, nausea, and shortness of breath, as well as other telltale markers of cardiac disease. Both sexes need to manage risk factors for cardiovascular disease, including smoking, high blood pressure, high cholesterol, obesity, and diabetes, as well as their own health. Good lifestyle choices, early intervention, and routine check-ups can reduce the risk of cardiovascular disease in both men and women. Men are usually more likely to have the disease than women are, whereas at the age of menopause, women's risk increases [54].
3. **Chest pain (CP):** Chest discomfort is a typical sign of heart disease[55]. This could be due to a number of conditions, including the following:
    - **Angina**: This is chest pain or discomfort caused by a lack of blood flow to the heart muscle. It is frequently caused by physical or mental stress and feels like squeezing or pressure in the chest, which is the main risk factor that can determine whether a person has the disease or not.
    - **Heart attack**: A heart attack happens when the blood supply to the heart muscle is suddenly cut off. During a heart attack, chest pain is frequently reported as crushing or heavy, and it may spread to the arm, jaw, or back. Shortness of breath, nausea, and sweating are all possible symptoms.
    - **Coronary artery disease**: This is a disorder in which the arteries that carry blood to the heart narrow or become clogged owing to plaque accumulation. When the blood supply to the heart is limited, chest discomfort can ensue.
    - **Aortic dissection**: This involves a riper in the inner layer of the aorta, which is the main blood vessel that transports blood from the heart to the rest of the body. Aortic dissection causes chest discomfort, which is typically characterized as tearing or ripping and may spread to the back.
    - **Pericarditis**: inflammation of the sac that surrounds the heart. Pericarditis causes intense chest discomfort that intensifies with heavy breaths or lying down.

Importantly, chest pain can be caused by a variety of factors, and not all chest discomfort is caused by cardiovascular illness. However, if one has chest discomfort, especially if it is severe or accompanied by other symptoms, one should seek medical assistance right away to discover the reason and obtain proper treatment.

4. **Resting blood pressure (trestbps) or high blood pressure** can injure arteries and increase the risk of heart disease and stroke disease[56]. An important risk factor for cardiovascular disease is blood pressure. One of the main risk factors for the development of cardiovascular diseases such as heart disease, heart attack, and stroke is hypertension or high blood pressure. The heart and blood vessels are strained when blood pressure is consistently high. Over time, this may result in damage to the arteries, particularly the coronary arteries that provide blood to the heart muscle. This raises the risk of developing conditions, including coronary artery disease, which can result in myocardial infarctions. Moreover, high blood pressure causes the heart to work harder to pump blood, which may lead to heart failure or an enlarged heart. Additionally, it may damage the brain's blood vessels, which increases the risk of stroke. It is vital. Monitoring blood pressure on a regular basis and maintaining it within a healthy range are essential. A blood pressure less than 120/80 mmHg is considered normal, according to the American Heart Association. A systolic pressure of 120–129 mmHg and a diastolic pressure of less than 80 mmHg are considered indicative of elevated blood pressure. A blood pressure reading of 130/80 mmHg or above is considered hypertension and is indicative of cardiovascular disease. Blood pressure can be regulated via dietary and lifestyle modifications, regular exercise, weight control, alcohol avoidance, and stress reduction. Medication may be recommended if lifestyle changes alone are not enough to regulate blood pressure. For the purpose of controlling cardiovascular health and maintaining blood pressure, routine visits to medical professionals are necessary.
5. **High blood cholesterol**: Cholesterol is another important factor in cardiovascular disease. Certain foods include cholesterol, a waxy substance produced by the liver [57]. While cholesterol is necessary for the body to operate at its best, high cholesterol levels can also lead to the development of cardiovascular disease. The two main types of cholesterol are low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol. Owing to its ability to build plaques in the arteries, which lead them to narrow and harden—a condition known as atherosclerosis—low-density lipoprotein (LDL) cholesterol is commonly referred to as "bad" cholesterol. This may result in limited blood flow to the heart and other organs, increasing the risk of heart attack and stroke. However, because HDL cholesterol helps eliminate fat, it is frequently referred to as "good" cholesterol. On the other hand, it helps remove LDL cholesterol from the bloodstream and returns it to the liver, where it is broken down and eliminated from the body. HDL cholesterol is frequently referred to as "good" cholesterol. The risk of

cardiovascular disease can be increased by both low HDL cholesterol and high LDL cholesterol levels. Elevated cholesterol levels can be caused by a poor diet, inactivity, obesity, smoking, and certain medical conditions. To monitor cholesterol levels, routine cholesterol testing is needed. The American Heart Association recommends that anyone 20 years of age and older receive cholesterol checked every four to six years or more frequently if they have cardiovascular disease risk factors. Changes in lifestyle that can help control cholesterol levels include quitting smoking, consuming less alcohol, maintaining a healthy weight, exercising more, and adopting a healthy diet low in saturated and trans fats. Medication may be advised if lifestyle changes alone are not enough to lower cholesterol levels. One of the most important factors in preventing and managing cardiovascular disease is lowering cholesterol levels. A healthcare professional is advised to determine appropriate cholesterol targets and create a customized cholesterol control plan. Normal cholesterol levels might change depending on the precise measurements and guidelines used. Nonetheless, the typical goal ranges for cholesterol levels are as follows:

A. **Cholesterol total:** A concentration of less than 200 mg/dL (milligrams per deciliter) is considered optimal.
B. **LDL cholesterol**: Less than 100 mg/dL is considered ideal for the majority of people. Individuals at a higher risk of cardiovascular illness, such as those with preexisting heart disease or diabetes, may benefit from a goal of less than 70 mg/dL.
C. **Higher levels of HDL** cholesterol are typically thought to be beneficial. An HDL level of 40 mg/dL or higher is preferred for men, whereas a level of 50 mg/dL or higher is preferred for women.
D. **Triglyceride** levels should be less than 150 mg/dL.

Importantly, these are only general recommendations, and specific goals may differ on the basis of factors such as age, sex, general health, and the presence of other cardiovascular disease risk factors. Healthcare professionals are advised to determine each person's ideal cholesterol goals and to create a customized cholesterol control strategy. To monitor cholesterol levels and assess cardiovascular risk, regular cholesterol exams are essential [57].

6. **Blood sugar or fasting blood sugar (fbs):** Blood sugar levels can influence the onset and course of cardiovascular disease[58]. Here's how it is done:
   A. **Diabetes**: Diabetes is characterized by high blood sugar levels. Diabetes puts people at increased risk of cardiovascular disease, such as heart attack, stroke, and peripheral artery disease. Elevated blood sugar levels can harm blood vessels and contribute to plaque development, resulting in atherosclerosis.
   B. **Insulin resistance**: Insulin resistance occurs when the cells of the body become less receptive to the actions of insulin, resulting in high blood sugar levels. Insulin resistance is frequently associated with obesity, high blood pressure, and excessive cholesterol levels, all of which are referred to as metabolic syndrome. The risk of developing cardiovascular disease is increased by metabolic syndrome.
   C. **Inflammation:** High blood sugar levels in the body can cause inflammation. Chronic inflammation is thought to contribute to the development of atherosclerosis and other cardiovascular diseases. Inflammation can damage blood vessels, encourage blood clot formation, and contribute to the course of cardiovascular disease.
   D. **Glycation:** Elevated blood sugar levels can cause glycation, a process in which sugar molecules bond to proteins in blood vessels. This can lead to the creation of advanced glycation end products (AGEs), which can induce oxidative stress and blood vessel damage, hence contributing to the development of cardiovascular disease.

Managing blood sugar levels via lifestyle changes such as a nutritious diet, frequent exercise, and medication (if needed) is critical to lowering the risk of cardiovascular disease in those with diabetes or insulin resistance. To monitor and regulate blood sugar levels properly, it is critical to collaborate with healthcare experts. Normal blood sugar levels might fluctuate based on the time of day and whether a person has just eaten. The following are the general principles for maintaining appropriate blood sugar levels:

A. **Fasting blood sugar levels (before eating):** A normal fasting blood sugar level is typically between 70 and 99 mg/dL (3.9 to 5.5 mmol/L).
B. **Postprandial blood sugar (after eating):** A typical postprandial blood sugar level is usually less than 140 mg/dL (7.8 mmol/L), which is tested 1–2 hours after a meal.

Importantly, these are only suggestions; individual goals may differ depending on factors such as age, overall health, and any underlying medical concerns. People with diabetes may have varying blood sugar management goal ranges, as set by their healthcare professionals.

Regular blood sugar monitoring is critical for maintaining general health and minimizing problems, especially for people with diabetes or those at risk of developing diabetes. If you are concerned about your blood sugar levels, it is best to receive specialized advice and counseling from a healthcare practitioner.

7. **Resting electrocardiographic results (restecg):** A noninvasive test that analyzes the electrical activity of the heart is a resting electrocardiogram (ECG or EKG). It can offer important information about the rhythm and pace of the heart, as well as any potential irregularities that may signal cardiovascular illness [59]. Some frequent ECG abnormalities that may indicate cardiovascular disease are as follows:
   A. **Arrhythmias** are irregular heartbeats. An electrocardiogram (ECG) can identify irregular cardiac rhythms such as atrial fibrillation, ventricular tachycardia, or bradycardia. These arrhythmias may be a sign of underlying cardiac disease.
   B. **The ST-segment changes**: On an ECG, the ST-segment reflects the time between ventricular depolarization and repolarization. ST segment changes, such as elevation or depression, might suggest myocardial ischemia or damage, which can be associated with diseases such as angina or heart attack.
   C. **Abnormalities in the T wave**: The T wave on an ECG reflects ventricular repolarization. T-wave abnormalities, such as inversion or flattening, might indicate myocardial ischemia, electrolyte imbalances, or other heart disorders.
   D. **Abnormalities in the QRS complex**: The QRS complex on an ECG reflects ventricular depolarization. QRS complex anomalies, such as extended QRS duration, might suggest conduction issues or ventricular hypertrophy, which may be linked with certain cardiovascular illnesses.

   Importantly, an ECG is only one tool for detecting cardiovascular illness; other assessments and tests may be needed to confirm a diagnosis. If you are concerned about your ECG readings or signs of cardiovascular illness, you should contact a healthcare expert for a thorough examination and proper management.
8. **thalach**: The maximum heart rate (MHR) is the highest number of times your heart can beat in one minute during maximum exertion. It is an individualized measure that varies from person to person and can be influenced by factors such as age, fitness level, and genetics [63]. As one engages in physical activities, the heart pumps oxygenated blood to the muscles to meet their increased demand. The heart rate gradually increases to meet the body's oxygen requirements

during exercise. Eventually, there is a point where the heart beats as fast as it can, reaching the maximum heart rate. For several decades, a commonly used method to calculate the maximum heart rate was the simple formula: MHR = 220 - age. However, this formula has been criticized for its lack of accuracy, with studies suggesting that it may overestimate or underestimate the true maximum heart rate. Therefore, individual variations are now taken into account, and alternate formulas such as the Tanaka method (MHR = 208 - 0.7 * age) have been proposed. The maximum heart rate is important in various fields, particularly exercise physiology, sports training, and health monitoring. Athletes and fitness enthusiasts often use their maximum heart rate as a guide to determine their exercise intensity, as different levels of effort exert different stresses on the cardiovascular system. By working within a certain percentage of their maximum heart rate, individuals can ensure that they are training in specific heart rate zones that target different fitness goals, such as fat burning or improving aerobic capacity.

Importantly, the maximum heart rate should be achieved only under controlled circumstances and with proper supervision. Pushing oneself to the absolute maximum heart rate can be dangerous and carries a risk of cardiovascular complications. Hence, it is always recommended to consult healthcare professionals and follow appropriate guidelines when determining exercise intensity and setting target heart rate zones.

9. **exang: Exang risk factors**, or risk factors for developing exang (also known as angina or angina pectoris) [64], include the following:
   A. **Age**: The risk of developing exang increases with age, particularly in individuals over the age of 55 for men and over the age of 65 for women.
   B. **Gender**: Men are more likely to develop exang than women are, especially at a younger age. However, this difference diminishes after menopause.
   C. **Smoking**: Tobacco and cigarette smoke contain harmful chemicals that damage blood vessels, reduce the oxygen supply, promote blood clotting, and increase the risk of exacerbations.
   D. **High cholesterol levels:** High levels of low-density lipoprotein (LDL) cholesterol, also known as "bad" cholesterol, contribute to the buildup of plaques in arteries, narrowing them and reducing blood flow to the heart muscle.
   E. **High blood pressure:** Long-standing hypertension can damage arteries and increase the risk of developing an exang. It adds strain to the heart and can promote the formation of plaques in the arteries.
   F. **Diabetes**: Individuals with diabetes are at increased risk of developing exangulation. High blood sugar levels can damage blood vessels and nerves, leading to reduced blood flow to the heart and pain during exertion.
   G. **Obesity**: Being overweight or obese increases the workload on the heart and increases blood pressure, cholesterol levels, and the risk of developing diabetes. These factors contribute to an increased risk of exang.
   H. **Family history**: Having a close relative, such as a parent or sibling, with a history of exang or heart disease increases an individual's risk.
   I. **Sedentary lifestyle**: A lack of regular physical activity and exercise can contribute to obesity, high blood pressure, and high cholesterol levels, which increase the risk of developing exang.
   J. **Stress**: Chronic stress, anxiety, and depression can increase the risk of developing angina and other cardiovascular diseases. Stress may also lead to unhealthy coping mechanisms such as overeating, smoking, or sedentary behavior.

Importantly, having one or more risk factors does not guarantee the development of an exang. However, adopting a healthy lifestyle, managing risk factors, and seeking medical care can significantly reduce risk and improve overall heart health.

10. **Oldpeak**: ST depression induced by exercise relative to rest ('ST' relates to positions on the ECG plot and is also known as ST depression induced by exercise relative to rest) is a measure used in assessing the severity of heart disease during exercise tolerance testing. A higher Oldpeak value typically indicates a greater risk of coronary artery disease[65].
11. **slope**: the slope of the peak exercise ST segment (value 1: upsloping, value 2: flat, value 3: downsloping). also known as the slope of the peak exercise ST segment, is another measure used in exercise tolerance testing to assess heart disease. A more negative slope value is generally associated with a greater risk of coronary artery disease [66].
12. **ca:** CA risk factors typically refer to the number of major coronary arteries affected by blockage or narrowing due to heart disease. The more coronary arteries affected, the greater the risk of complications such as heart attack or other heart-related issues. It is an important factor to consider when evaluating the severity and prognosis of coronary artery disease. In addition, the number of major vessels is (0--3) [67].
13. **thal**: A thal risk factor typically refers to thalassemia, a group of inherited blood disorders characterized by the body making an abnormal form or inadequate amount of hemoglobin, the protein in red blood cells that carries oxygen[68]. These conditions result in excessive destruction of red blood cells. A blood disorder called thalassemia has multiple forms (3 = normal; 6 = fixed defect; 7 = reversible defect).

    It is important to manage and control these risk factors through lifestyle changes, such as adopting a healthy diet, exercising regularly, quitting smoking, and managing stress, as well as through medical interventions when necessary. To prevent any type of heart disease, regular checkups should be performed, blood pressure and cholesterol levels should be monitored, the suitability of weight for height should be checked, healthy and dietary foods should be eaten, smoking should be stopped, and stress should be managed[69].

4. Making healthcare simply available

The Internet of Things has revolutionized healthcare by enabling the seamless integration of medical devices and sensors. IoT medical devices, such as wearable monitors, smartwatches, and implantable sensors, can continuously collect physiological data such as heart rate, blood pressure, and electrocardiogram (ECG) signals. To increase the ease of availability for simple users, real-time data streams serve as valuable inputs for making diagnoses available. In addition, real-time implementation of the pulse sensor costs only approximately 16.05 dollars, which is calculated in Table 2. Heartbeat is one of the main factors that could help in making the first decision about heart status, whether it is normal or not, and is based on the Clevelend Clinic.

4.1. Step One: Available sensor used for measuring the situation of the heart

Multiple sensors, such as a heartbeat sensor, an echocardiogram (ECG) sensor, an electrocardiogram sensor, a blood pressure sensor, a cholesterol sensor, a cardiac MRICT scan, and a Holter monitor, can be used to measure and diagnose a patient to determine whether he or she has the possibility of having heart disease in general or not.

sensor, and an implantable device, a heartbeat sensor is the main and basic way to make the first decision about heart disease.

Therefore, this study aims to show a simple user how he or she could make a simple measurement for having a heartbeat rate and making the first decision about heart status[70-72].
While many sensors exist, most studies have concentrated on two types of main sensors: heartbeat (pulse sensor) and ECG sensors, which are represented in Figures 5 and 6. It could help predict a person's status. Therefore, IEEE, Springer, and Elsevier clarified its use in multiple real-time diagnoses of cardiovascular disease, and the number of these sensors in their studies is mentioned in Table 3. It is commonly used for measuring the situation of the heart and making the first decision about whether it is okay or not.

4.2. Step Two: Methodology used for simple availability.

The methodology that followed to have this model simply available was hardware and software design. Hardware design includes selecting sensors, microcontrollers, and other necessary components. In this case, Arduino Uno and pulse sensors are used to measure the patient's heart rate, as represented in Figure 9.
he heartbeat simulator comprises two main parts: hardware and software components. The hardware component consists of an Arduino Uno board and a pulse sensor. The software component includes the Arduino IDE and Proteus software. To design and simulate heartbeats via Arduino and Proteus, steps were taken, and a lower cost was used to assess the status of heart disease.

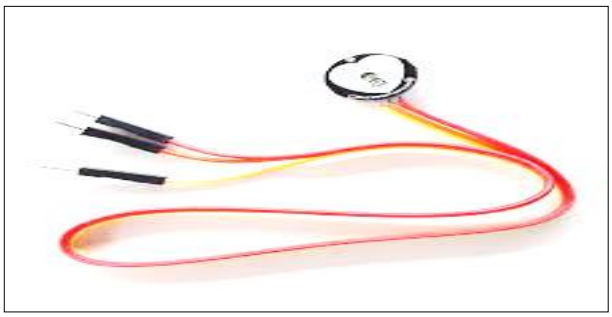

Figure 5. Pulse sensor

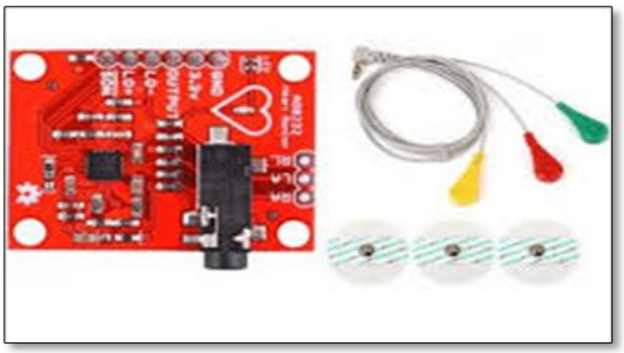

Figure 6. ECG sensor

4.3. Step Three: Proteus simulation

In this simulator, the use of an Arduino Uno is the main method for measuring the electrical activity of the heartbeat according to the ability of the pulse sensor to measure heart conditions. In this simulation, we need an Arduino Uno, a pulse sensor, connecting wires virtually, and a pulse sensor as a method to read the heartbeat of the patient and make the first decision about the heart status. It also has the ability to know whether the method of checking the heart situation is right or not. To simulate the heartbeat, the program is uploaded to the Arduino board. Then, the Arduino is connected to the Proteus software, which acts as a virtual oscilloscope. The oscilloscope is used to display the heartbeat waveform generated by the Arduino; Figures 7 and 8 present the simulation and oscilloscope work.

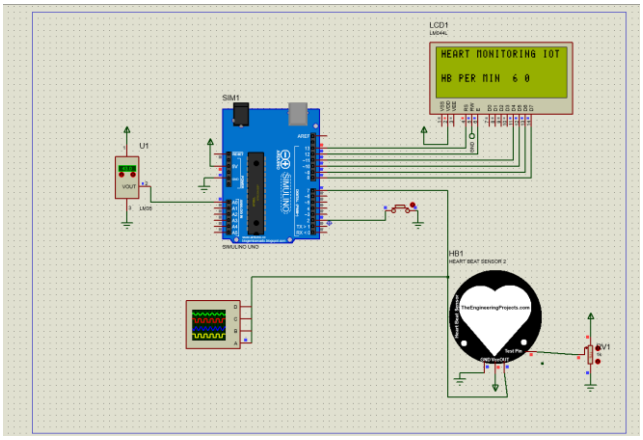

Figure 7. Proteus simulation for healthcare simply available

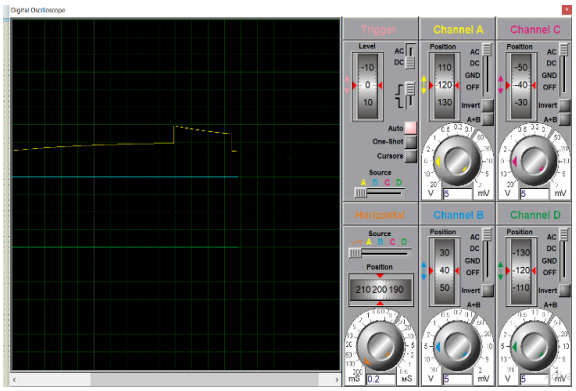

Figure 8. Oscilloscope for healthcare simply available (heartbeat)

4.4. Step Four: Hardware design and real implementation using an Arduino unit and pulse sensor

To make this model simple and feasible, as suggested by the Arduino Uno pulse sensor, a connected wire is used. Arduino Uno is a cost-effective sensor board used to measure the electrical activity of the heartbeat via a pulse sensor, which produces the heartbeat as the first status and is simple to check and represent as an analog reading. The hardware design involves connecting an Arduino Uno board to a pulse sensor. The positive end is connected to the digital pin with 5 volts on the Arduino board. The negative end of the pulse sensor is connected to the ground of Arduino. The data end is connected to any analog pin, and we use A0, as represented in Figure 9.

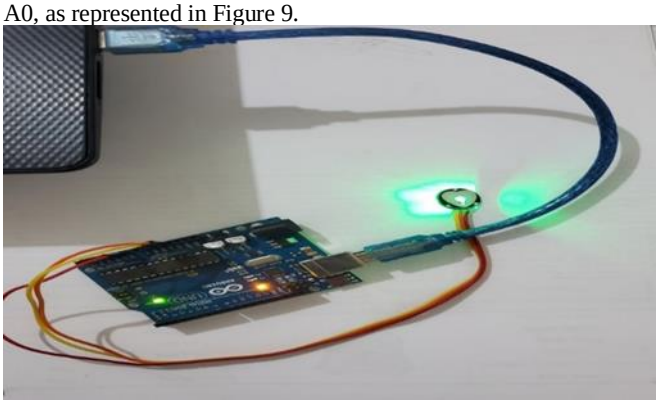

Figure 9. simply available real time implementation of healthcare using pulse sensor

5. Results

The cost of making healthcare devices more available or simply available via simple materials is only 16.05 dollars. The results of the heartbeat simulation using the Arduino and Proteus software are shown in Figures 7 and 8 and are simple. Real-time work is also represented in Figure 8, and the final result is clarified in Figure 10, which represents the use of serial heart rate monitoring. The real-time implementation represents heart monitoring per minute, as shown in Figures 8 and 9. It represents the electrical impulses of the heart. On the basis of the status of the checked person at age 22, his heart appears normal according to the heart rate measure that was already taken from the Clevelend clinic, which represents a person older than 18 years, and the normal heart beat is between 60 and 100; it appears between 64 and 79, which represents a normal status.

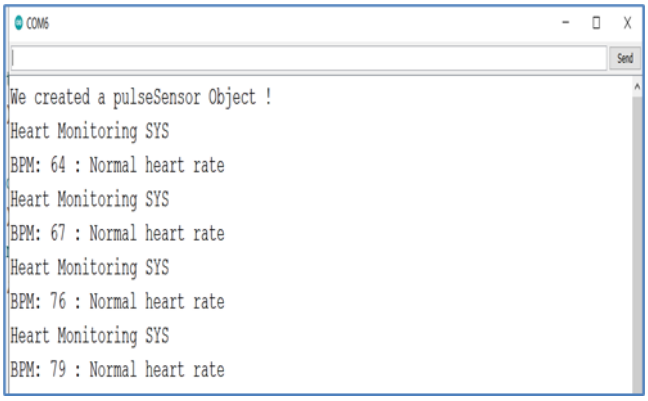

Figure 10. Serial heart rate monitoring

6. Conclusion and future work

Cardiovascular disease is one of the most fatal diseases in the world. Usually, early diagnoses prevent any type of cardiovascular disease. Collaboration among researchers, healthcare professionals, and technology developers is crucial to translating this potential into practical clinical applications. This work highlights being aware of the most common forms of cardiovascular disease, understanding how much it costs to develop a real-time heart diagnostic, being aware of the most widely utilized criteria for cardiovascular disease, deciding if the heart is functioning normally, determining how many studies utilized ECG and pulse sensors to estimate heartbeat from 2017--2023, enabling even the novice user to attempt a heart check with this experiment, and being aware of the fundamental tools used to assess heart health.

In future work, a new smart healthcare system that integrates the smart IoT with deep learning, which helps not only in increasing prediction accuracy but also in solving power consumption, methods of connection, and security processes, is proposed.

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Table 2: Real cost of implementation of a pulse sensor for healthcare diagnosis

Models	**Data extracted**	**Price for having the devices**
Heart beat **model**	Heart beat only	Arduino-uno (10.45$) Wires (1.80$) Variable transistor (0.27$) Pulse sensor (3.60$) LCD Monitor(optional) Total=16.05$

***Price taken on 22/7/2023 when the price of dollars 1$=555 YR**

Table 1: Risk factors that are used in most datasets for monitoring cardiovascular disease.

Dataset	**Risk factors**	**Number of attributes**	**Result**
Cleveland :303 **Hungarian: 294** **Switzerland: 123** **Long Beach VA: 200** **Statlog : 270**	Age: age in years Sex: sex (1 = male; 0 = female) cp: chest pain type Value 0: typical angina Value 1: atypical angina Value 2: nonanginal pain Value 3: asymptomatic trestbps: resting blood pressure (in millimeters of mercury at hospital admission) chol: milligrams/dl of serum cholesterol fbs: (fasting blood sugar > 120 mg/dl (1 = true; 0 = false) restecg: resting electrocardiographic results Value 0: normal Value 1: having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV) Value 2 demonstrating definite or likely left ventricular hypertrophy according to Estes' criteria thalach: highest heart rate reached. exang: indicates exercise-induced angina (1 = yes, 0 = no). oldpeak = ST depression caused by activity compared to rest. slope: the slope of the peak exercise ST segment Value 0: upsloping Value 1: flat Value 2: downsloping ca: number of main vessels (0-3) colored by flourosopy thal (Thalassemia): 0 = normal; 1 = fixed defect; 2 = reversable defect and the label	13 and one for predication result	Normal or not

Table 3: Most Used Sensor for Real Time Diagnosis of Cardiovascular diseases

Publisher	Sensor used	Number of studies that used this sensor	Years
Elsevier	ECG sensor	1073	2017
		1158	2018
		1297	2019
		1575	2020
		1901	2021
		2003	2022
		1528	2023
	Heart beat sensor	473	2017
		596	2018
		673	2019
		797	2020
		958	2021
		1088	2022
		844	2023
IEEE	ECG sensor	252	2017
		271	2018
		279	2019
		248	2020
		313	2021
		367	2022
		110	2023
	Heart beat sensor	22	2017
		18	2018
		19	2019
		24	2020
		34	2021
		29	2022
		16	2023
Springer	ECG sensor	441	2017
		512	2018
		585	2019
		626	2020
		728	2021
		852	2022
		740	2023
	Heart beat sensor	360	2017
		413	2018
		441	2019

	480	2020
	496	2021
	620	2022
	432	2023